positions after the current combined image beam position. Furthermore, the reflections of the projected combined image beams incident on the remote surface, in addition to the tracer beam, may be optionally detected and compared with a copy of the image in a memory. And based on that comparison, the subsequent estimated positions of the projected image beams can be adjusted on subsequent pseudorandom sweeps, progressively, to improve the projected image's sharpness, brightness, and color. The combined image beam may also include information about a known image to be displayed.

[0031] For hundreds of millions of users using billions of computing devices, the availability of a physically small, low-power, high-quality, high reliability, high resolution projection display with few or no visual artifacts may provide a significant advantage. These advantages may be particularly significant for devices with small displays, such as mobile phones and PDA's. With a small, low-power, built-in micro projector, such small computing devices can display information, effectively, on a large, high-resolution screen without the large physical size and high power consumption rate normally associated with a large screen.

[0032] Power efficiency is also very important, particularly for small personal devices, because of the limited battery life with daily use. Efficient projection of light with limited use of filters, polarizers, and the like, reduces overall power consumption, while providing a high quality display. The mixing of light falls into at least two general categories: additive mixing and subtractive mixing. In additive mixing, component light signals are combined with each other. In subtractive mixing, some light frequency components are filtered out, transmissively or reflectively, or subtracted from the original whole. Some of the conventional display technologies, such as LCD and DLP, use subtractive mixing as a basic part of their operation. Subtractive mixing of light beams is generally wasteful of energy because light (photons) is first generated and then partially blocked (subtracted), wasting the already generated light. Subtractive mixing is used to increase image brightness and enhance contrast between the brightest and darkest pixels. In display systems that use subtractive mixing, often just five percent (5%) of the energy used to generate the light is eventually utilized for displaying the image, resulting in poor overall efficiency.

[0033] Another important aspect of a display technology is reliability. With few moving parts, low power consumption, and low heat generation, reliability of invention may be generally greater compared to other display technologies having similar quality.

[0034] The feedback aspects, for both tracer pulses and image beam, of the invention enables uses in applications that are not possible, or are more difficult to realize, with other technologies. For example, the invention allows automatic adjustment of a display in real-time based on a perspective/position of the viewer/user. The user may move around a remote display screen while the invention automatically adjusts the displayed image to provide the appropriate perspective as viewed from each new position of the user with respect to the direction of projection onto the screen. This feature may have uses in immersive applications, such as video games. A variation of this capability is that the projected image may be displayed on an un-even surface of a screen, such as a textured wall, fabric, or other background with texture or curvatures that would otherwise distort the projected image. These features are more fully described below with respect to FIGS. **3-7**.

[0035] Even though various embodiments refer to the RGB color space, other color spaces may also be used. For example, YIQ, YUV, YCbCr, and the like, color spaces may also be used to provide an image for projection. Similarly, more than three basic colors may be used. For example, in addition to the Red Green Blue color sources, other emissive spectral component color sources may be used, such as an Orange color source, for example, in the wavelength range of 597 to 622 nanometers (nm), a Yellow color source, for example, in the wavelength range of 577 to 597 nm, or a Violet color source, for example, in the wavelength range of 380 to 455 nm. In this way, four or more component color sources may be used to project the image on a remote surface.

[0036] Generally, use of additional component colors may remove some tradeoffs, for example, the tradeoffs between efficiency, efficacy (characterized as perceived lumens per watt), gamut (broadest color range), and fidelity, characterized by avoidance of perceptive artifacts, such as spatial, temporal, motion, or color artifacts. Such tradeoffs may have to be made in both spatially rasterized and field-sequential color display systems, like LCDs, having addressable display elements or pixels. The use of a greater number of coherent monochrome sources, such as laser beams, reduce speckle that may be caused by self-interference in the reflected beam of each component light beam. The greater number of component light beams may reduce speckle because the component light beams are not coherent with respect to each other and may cancel out.

[0037] Multiple component light sources of substantially identical wavelength may also be used for added peak power and efficiency. For example, multiple semiconductor light sources, such as LEDs and laser LEDs, may be optically combined to generate a brighter and more efficient light beam. Speckle may be reduced due to reduced phase coherency in such "gang source" systems where multiple near-identical wavelength component light sources are used.

Illustrative Operating Environment

[0038] Electronic displays for computing devices, such as workstations, desktop and laptop Personal Computers (PC), mobile devices like mobile phones, PDA's, and the like, as well as displays for entertainment-oriented devices, such as televisions (TV), DVD players, and the like, may be replaced or supplemented by image projection device (IPD). In one embodiment, the IPD is an integral part of the computing or entertainment device. In another embodiment, the IPD may be a supplemental external display device used in addition to, or in place of, a conventional display.

[0039] One embodiment of a computing device usable with the IPD is described in more detail below in conjunction with FIG. **2**. Briefly, however, the computing device may virtually be any stationary or mobile computing device capable of processing and displaying data and information. Such devices include mobile devices such as, cellular/mobile telephones, smart phones, display pagers, radio frequency (RF) devices, infrared (IR) devices, PDAs, handheld computers, laptop computers, wearable computers, tablet computers, mobile video game consoles, integrated devices combining one or more of the preceding devices, or the like. Stationary computing devices may also include virtually any computing device that typically connects using a wired or wired communications medium such as personal computers, video